Present-day Martian Dune Gully Formation.

S. Diniega[1], S. Byrne[2], C. M. Dundas[2], A. S. McEwen[2], and N. T. Bridges[3], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., MS 183-401, Pasadena CA 91109 (serina.diniega@jpl.nasa.gov), [2]Dept. of Planetary Sciences, The University of Arizona, [3]Applied Physics Laboratory, John Hopkins University.

Martian slope gullies (composed of an alcove, channel, and apron) have been the focus of much controversy in recent years, as scientists seek to understand how they develop and what they imply about the martian environment. Formation theories have involved a wide range of environmental conditions and processes, such as groundwater eruption [1, 2], the melting of snow or ice following climate change [3, 4], or dry granular f ow [5, 6]. However, a dearth of observations or information about the environmental setting of slope gully formation has made it diff cult to evaluate among competing theories.

Last year [7], we presented a survey of slope gullies found on martian dunes in the southern hemisphere – a class of gullies that had been neglected in previous slope gully studies. Using MOC, CTX, and HiRISE images, we identif ed dune gullies within 19 gullied dune f elds, seven of which had suff cient overlapping high-resolution coverage for identif cation of gully activity within the last six martian years, such as alcove/channel formation and widening and apron extension between images. We found that the timing of def nite morphologic changes as well as signatures of recent activity (albedo and textural signatures that were associated with recent apron deposition, and which faded soon after appearing and did not re-appear in subsequent years) constrained activity to the southern winter season.

Based on these f ndings, we hypothesized the existence of a seasonal control on current dune gully activity – the accumulation and/or sublimation of CO_2 frost, which is consistent with observations of dune gully activity within the North Polar Erg [8]. Additionally, as these dune gullies were similar to non-dune slope gullies in shape and timing of activity [9], we proposed that further monitoring of dune gully activity would yield detailed information about present-day general gully formation and modif cation processes.

New observations: Over the recent winter season, we closely monitored three active dune gullies so as to better identify the timing and sequence of activity (Figure 1). Based on these observations, along with further observations of activity within non-dune slope gullies [10], we are beginning to quantitatively understand present-day gully formation and modif cation processes.

As shown in Figure 3, large-scale activity at all three sites, such as alcove retreat or formation or channel down-cutting, primarily occurred at the end of winter, within a narrow time period (∼Ls 120-160). Only one example of large-scale activity (10m retreat of a small alcove's edge) occurred within autumn. This implies a type of 'threshold' dynamic for (most) gully formation activity, and work is ongoing to identify the exact seasonal mechanism(s).

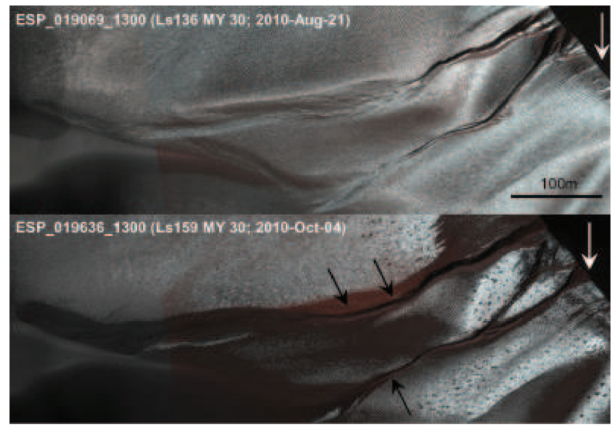

Figure 1: HiRISE images of dune gullies within Matara crater that were closely monitored this past winter. This site has been active several times since 2005, with the most recent activity including channel widening and down-cutting into the apron (black arrows) and the formation of an alcove and 5m-wide channel (white arrow).

Small-scale activity (consisting of dark, roughly linear 'f ow' features) begins in autumn (∼Ls 60) and continues through the end of winter. Individual f ows are generally very thin (0.5m wide) and long (up to 400m), extending from the alcove base down onto the pre-existing apron or dune surface. These extend over (without obscuring) ripples and small-scale topography, and correspond to areas within channels and alcoves where material has been disturbed/the channel has changed/is inf lled. As winter progresses, some of these 'f ows' grow in width and form debris fans, instead of remaining linear.

Additionally, pits (2-5m in diameter) were seen to form on the aprons, some at end of thin (<1m width) and short channels (Figure 2). These appear morphologically similar to Type I dune gullies [11], but are of a much smaller-scale than the closely studied dune gullies in Russell crater and other dune f elds. These features seem to degrade quickly, explaining why they have been diff cult to detect in previous images. Work is ongoing to better constrain the locations and timing of this type of activity, and to understand if this activity is related to the formation of Type I dune gullies.

Implications: Several types of dune-gully activity have been observed over the past winter season – differing in timing, scale, and resultant morphologies. However, the observed differences were roughly consistent over three dune gullies (in two dune f elds), suggesting that the observed sequence of activity is representative of general dune-gully processes and can provide better constraints on timing and rates. Additionally, by acquiring a better understanding of activity within these three dune gullies, we may perhaps begin to differentiate between different present-day gully formation and modif cation processes operating on non-dune slopes, which has important implications for studies aiming to understand the observed slope-gully population.

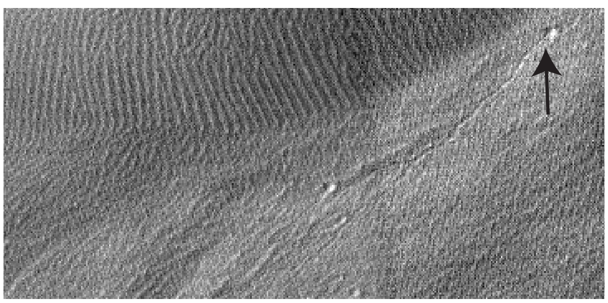

Figure 2: HiRISE image ESP_020203_1300, showing new pits on the apron of an active dune gully within Matara crater. Some of these pits appear to be the terminal end of small channels (black arrow), yielding similar morphology as type I dune gullies. The ripples along the top have wavelength of 3-4m.

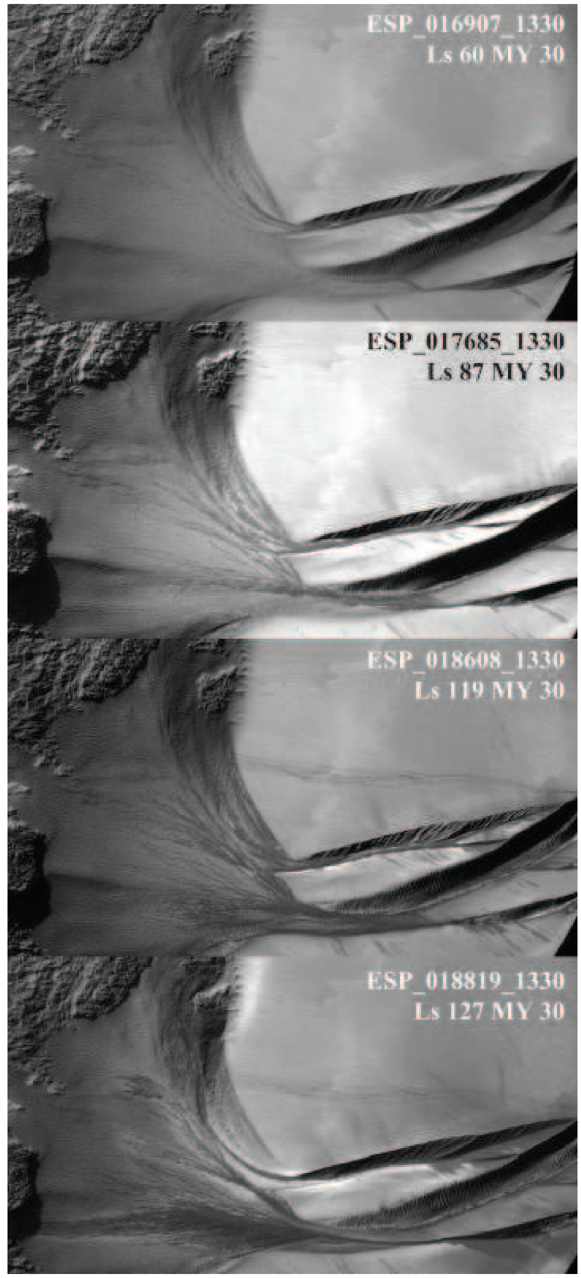

Figure 3: HiRISE images of a dune gully within Kaiser crater that was also closely monitored this past winter. Activity begins in autumn with thin, dark f ows (top 2 images: Ls 60 and 87). These f ows will continue forming throughout the winter season and thicken as the season progresses, forming new fans (Ls 119 and 127) and even new alcoves and channels (Ls 127). The debris that collapsed from the alcove and carved a new channel into the pre-existing apron is of suff cient volume and energy to overtop the rocky topography (black arrow). Images are 850m wide.

References

[1] M. C. Malin and K. S. Edgett. *Science*, 288: 2330–2335, 2000. [2] M. T. Mellon and R. J. Phillips. *JGR*, 106:23165–23180, 2001. [3] P. R. Christensen. *Nature*, 422:45–48, 2003. [4] J. L. Dickson, J. W. Head, and M. Kreslavsky. *Icarus*, 188:315–323, 2007. [5] A. H. Treiman. *JGR*, 108:8031–+, 2003. [6] J. D. Pelletier et al. *Geology*, 36(3):211–214, 2008. [7] S. Diniega et al. *Geology*, 38(11):1047–1050, 2010. [8] C. Hansen et al. *AAS DPS meeting* 42:Ab. 30.22, 2010. [9] C. M. Dundas et al. *GRL*, 37:L07202, 2010. [10] C. M. Dundas et al. this conference, 2011. [11] D. Reiss et al. *GRL*, 37: L06203, 2010.